4. APTA PR-PS-S-004-99, Rev. 2 Standard for Low-Location Exit Path Marking

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Abstract: This standard contains minimum requirements for an emergency low-location exit path marking system (LLEPM) for all passenger rail cars using passive (non-electrically powered illumination) and/or active (electrically powered illumination) means of marking the exit path(s) to safety.

Keywords: emergency exit, exit path, low-location exit path marking system (LLEPM)

Introduction

(This introduction is not a part of APTA PR-PS-S-004-99, Rev. 2, Standard for Low-Location Exit Path Marking.)

Review of past passenger rail accidents involving passenger and train crew emergency evacuation has indicated that, in certain cases, both passengers and emergency responders lacked sufficient information necessary for expedient emergency egress and access due to the absence of clear markings and instructions. The lack of adequate signage in conjunction with lighting system failures and/or low levels of illumination during conditions of darkness when these accidents occurred were cited as a cause for confusion and as a contributing factor to the injuries and casualties that resulted.

To address these concerns, the National Transportation Safety Board (NTSB) made the following recommendations to the Federal Railroad Administration (FRA), after investigation of a 1996 passenger train accident:

> "Issue interim standards for the use of luminescent material, retroreflective material, or both to mark all interior and exterior emergency exits in all passenger cars as soon as possible and incorporate the interim standards into minimum car standards." *(FRA R-97-16)*, and
>
> Require all passenger cars to contain reliable emergency lighting fixtures that are each fitted with a self-contained independent power source and incorporate the requirements into minimum passenger car safety standards *(R-97-17).*"

In 1998, the FRA issued regulations requiring that the interior of doors intended for emergency egress be lighted or conspicuously and legibly marked with luminescent material, that emergency window exits be conspicuously marked with luminescent material, and that clear operating instructions be posted at or near each such door and window exit. The FRA issued regulations in 1999 that require emergency lighting for new equipment.

This American Public Transportation Association (APTA) standard was developed to establish minimum requirements for low-location exit path marking (LLEPM) intended to provide visual guidance for passengers and train crewmembers to locate and operate primary exits during conditions of darkness when the emergency lighting system has failed or when smoke conditions obscure overhead emergency lighting.

An effective systems approach uses this standard, as well as APTA standards *APTA PR-E-S-013-99, Rev. 1 Standard for Emergency Lighting System Design for Passenger Cars* and *APTA PR-PS-S-002-98, Rev. 3, Standard for Emergency Signage for Egress / Access of Passenger Rail Equipment*[1], to provide a means for passengers and train crewmembers to locate, reach, and operate emergency exits to facilitate their safe evacuation in an emergency. Each railroad and car builder should carefully consider the options available to meet emergency evacuation requirements presented in these three standards.

Revision 1 of this Standard included: 1) reorganization of Section 1 Overview (to include Scope); 2) renumbering of References to Section 2 and inclusion of citations for 49 CFR regulations, and ASTM and UL standards; 3) addition of definition (marking) and inclusion of abbreviations and acronyms in

[1] For references in Italics, see Section 2 of this Standard.

Section 3; 4) revision of Section 5 headings; and 5) movement of material safety to a separate section 6 and renumbering of the remaining sections. In addition, 6) the bibliography was moved to Annex A; 7) the information formerly contained in Annex A was expanded upon (now included in Annex D); and 8) two new annexes were added to provide railroads with extensive guidance for evaluating passive LLEPM material performance.

Revision 2 of this Standard includes extensive modifications to enable the incorporation of this APTA standard by reference by the FRA in 49 CFR, Part 238. These modifications include:

1) revision of this Introduction;
2) revision of Purpose and Scope in Section 1 Overview;
3) addition and revision of several definitions in Section 3;
4) reorganization and revision of Sections 4 General requirements and 5 System design requirements;
5) deletion of Section 6 Material Safety;
6) relocation and revision of light meter requirements and HPPL laboratory tests and charging light test provisions that were formerly in Annex B to a new Section 6 Evaluation Measurements and Tests; and
7) revisions to Section 9 Maintenance to include additional and revised daily and periodic tests, and addition of defect reporting, repair, and recordkeeping.

Finally, revisions were made to the Annexes:

1) the technical considerations information formerly in Annex D was revised and relocated to Annex B;
2) test laboratory information in Annex C was revised and relocated as Annex D; and
3) three new Annexes were added that contain guidance for (Annex E), HPPL charging light illuminance measurement (Annex C), automatic testing of LLEPM systems that use independent power sources (Annex E), and representative sampling (Annex F).

As FRA was considering requiring the installation and of LLEPM systems on passenger rail equipment, APTA proposed to the Railroad Safety Advisory Committee (RSAC) Passenger Equipment Working Group / Emergency Preparedness Task Force that this APTA LLEPM standard be incorporated as a reference into 49 CFR, Part 238. Accordingly, APTA has worked with the FRA, railroads, car manufacturers and suppliers, labor organizations, passenger organizations, and NTSB, as part of the FRA RSAC process, to prepare Revision 2 of this standard in order to address an NTSB recommendation and to facilitate the incorporation by reference of the standard into the FRA regulations. The RSAC Task Force had little difficulty reaching consensus on the revisions as they apply to new equipment. However, the debate on how to handle equipment currently in service proved to be more difficult.

The modifications comprising Revision 2 of this standard will affect equipment currently in service and/or new equipment in the following ways:

- The date by which full compliance must be achieved has been extended from January 1, 2006 to January 1, 2009. See Section 1.1. Exceptions are allowed in Section 5.

- The option to accelerate installation of LLEPM systems to meet Emergency Light Levels required by *APTA PR-E-S-013-99, Standard for Emergency Lighting System Design for Passenger Cars compensate*-contained in Revision 1 of this standard has been eliminated.

- The Scope has been revised to clarify that the standard does not apply to tourist, scenic, historic, excursion operations, or private rail cars. See Section 1.1.

- The purpose of the standard has been revised to require tests to validate the design of the emergency sign / marking system. See Section 1.2.

- Several definitions have been added, including: auxiliary power system, car, color temperature, dual mode, foot-candle, head-end power, independent power source, emergency lighting, normal lighting, luminaire, luminous intensity, representative car, secondary exit, sign, spatial average and useful field of view. These additional definitions are necessary to clearly define requirements contained in the standard. See Section 3.1.

- The definition of HPPL material has been changed. See section 3.1.13. Railroads and manufacturers requested this change to eliminate the need for more than one type of HPPL product to comply with the requirements in this standard. Some passive LLEPM System components may have to be replaced or some illumination levels increased.

- The equivalency review committee requirement contained in Revision 1 has been eliminated and is replaced with greater flexibility in the installation of the LLEPM system.

- The requirement for the LLEPM system to visually mark an exit path in two directions has been deleted and replaced with new requirements for alternate exits that must be followed when a car has only one primary exit. Railroads are required to use their passenger awareness programs to alert passengers in these cases. See Section 5.

- For passenger cars ordered before April 7, 2008, and placed in service before January 1, 2011, electrically powered path markings/delineators that are not dual mode shall have an independent power source by January 1, 2012.

- Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests. See Section 5.1.2. An exception is allowed for certain semi-permanently coupled train sets by January 1, 2012.

- Additional flexibility has been included in cases where car interior configuration makes compliance with the maximum permitted spacing between markings / delineators/ light fixtures not practicable. See Sections 5.1.2.1 and 5.1.2.2.

- The terminology used to describe active LLEPM systems has been changed to allow newer technology actively powered marking /delineator components. See Section 5.2.1.

- Because fluorescent light sources are much more effective for charging HPPL material, fluorescent charging light sources are used as the basis for charging requirements. Different charging light levels are required when using different light sources (e.g., higher light levels are required when using incandescent lighting. See Section 5.2.2.2, Table 1.

- The specifications for the light meter required to confirm charging light levels have been revised and moved into the body of the standard. This means some railroads/suppliers may have to buy new meters. See Sections 5.2.2.2, and 6, and Annex C.

- As of April 8, 2008, all passive LLEPM System components must achieve HPPL performance or be specifically grandfathered. See Section 5.3 for grandfathering details.
- Zinc sulfide passive components in cars currently in service must be replaced and existing stocks of zinc sulfide components are no longer acceptable for installation as replacements because they do not meet HPPL performance. See Sections 3.1.13 and 5.3.
- Existing stocks of non-zinc sulfide photoluminescent material held in inventory as of April 7, 2008, can only be installed as allowed by Section 5.3
- Requirements have been added to the body of the standard for illuminance/luminance measurements and tests to verify that passenger car designs comply with this standard. These requirements where developed from material contained in the Annexes of Revision 1 of the Standard. Revision 2 makes these measurements and tests mandatory. See Sections 5.2 and 6.
- For equipment placed in service before January 1, 2008, if a verification of compliance test on a representative car LLEPM layout has not already been completed, as required by Section 6, it must be done by December 31, 2008. See Section 6.1.
- For new equipment, a verification of compliance test on a representative car / area, as required by Section 7, must be completed before the car is put into revenue operating service. See Section 6.1.
- A requirement to keep records of the illuminance/luminance measurements and tests made to verify initial designs has been added. See Section 6.3
- Requirements for material safety contained in Section 6 of Revision 1 of this standard have been deleted for Revision 2.
- More detail has been added to the System Reliability Requirements including a date extension for LLEPM components to function independently of the main car battery to on or after January 1, 2012. See Section 7.
- For passenger cars ordered on after April 7, 2008, or placed in service for the first time after January 1, 2011, a requirement for batteries or other independent power sources to operate in all orientations has been added. See Section 8.
- Extensive revisions have been made and detail added to the periodic tests and inspection requirements. See Section 9.
- Testing of a representative sample of the railroad car fleet must be done at an interval not to exceed 8 years to verify that the performance of the LLEPM components remains in compliance with this standard. See Sections 9.2.1, and 9.2.2.
- An explicit requirement has been added to repair LLEPM defects found during periodic inspections. See Section 9.3.
- All of the Informative Annexes in Revision 1 of this standard have been extensively revised and reorganized, and new annexes containing guidance information have been added.

Participants

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APTA PR-PS-S-004-99, Rev.2
Standard for Low-Location Exit Path Marking

1. Overview

Passenger rail car accidents have occurred resulting in the failure of the emergency lighting system during conditions of darkness. In addition, fire and/or smoke-filled car/compartment conditions may substantially increase the difficulty of evacuating passengers and/or train crewmembers. Because smoke generally rises, illumination from conventional emergency lighting fixtures, operating as intended, may be obscured. In these situations, the most viable escape path is most visible at or near the floor.

This standard requires that each passenger rail car have a low-location exit path marking (LLEPM) system, visible in the area from the floor to a horizontal plane 4 feet (1.22 m) above the aisle of the rail car to direct passengers to exit the affected car to the adjacent car (or, at the option of the railroad, off the train). This LLEPM system, located in the relatively clear air near the rail car floor, is intended to assist passengers and train crewmembers in identifying the path to exit the rail car in an emergency, under conditions of darkness and / or smoke.

Passenger railroads recognize that, in the majority of emergencies, the safest place for passengers and crew is on the train. Should evacuation from a particular car be required, the safest course of action for passengers and crew is normally to move into an adjacent car. This avoids or minimizes the hazards inherent with evacuating passengers onto the railroad right-of-way. However, in certain emergencies, evacuation from the train onto the right-of-way may be the safest alternative. While this standard requires that the LLEPM system direct passengers along a path that leads passengers into an adjacent car, railroads may design and install the LLEPM system components to also direct passengers to side doors for evacuation off the train. If railroads choose this option, their passenger safety awareness programs should emphasize the circumstances under which passengers should make the decision to evacuate the train, rather than move into an adjacent car, as well as safe movement on the railroad right-of-way.

APTA designed this standard to offer flexibility in its application, as well as to achieve the goal of facilitating passenger and train crew egress from potentially life-threatening situations on passenger rail cars. Individual railroads have the responsibility to design, install, and maintain an LLEPM system that is compatible with their internal safety policies for emergency evacuation, while complying with the performance criteria specified in this standard.

1.1 Scope

This standard applies to all passenger rail cars that operate on the general railroad system in the United States. This standard does not apply to tourist, scenic, historic, excursion operations, or private rail cars.

Unless otherwise specified, Revision 2 of this standard takes effect April 7, 2008. All passenger cars shall comply by January 1, 2009, except as noted in Section 5.

This standard is an integral component of a systems approach to locate, reach, and operate emergency exits to promote the safe evacuation of passengers and crewmembers in the event of an emergency. The other required components of this systems approach are emergency lighting and emergency signs, which are described in the following APTA standards:

APTA-SS-E-013-99, Rev. 1, Standard for Emergency Lighting System Design for Passenger Cars[2], and

APTA-SS-PS-002-99, Rev. 3, Standard for Emergency Signage for Egress / Access of Passenger Rail Equipment.

1.2 Purpose

This standard establishes requirements for the selection of the physical characteristics, informational content, and placement of LLEPM systems for installation within passenger rail cars to provide consistent identification of primary exits and secondary exits, under certain conditions (see Section 5), and the path to follow to reach such exits. This standard also requires tests to validate the LLEPM design.

Complementary emergency systems provide emergency lighting and emergency signage / marking to locate, operate, and reach emergency exits and are covered in other standards.

2. References

This standard shall be used in conjunction with the applicable sections of the following publications. When the following publications are superseded, the revisions shall apply.

ANSI/ASQC Z1.9-1993, Sampling Procedures and Tables for Inspection by Variables.

APTA PR-E-RP-007-98 Recommended Practice for Storage Batteries and Battery Compartments.

APTA PR-E-RP-012-99, Recommended Practice for Normal Lighting System Design for Passenger Rail Equipment.

APTA PR-CS-S-012-02, Standard for Passenger Car Door Systems for New and Rebuilt Passenger Cars.

APTA PR-E-S-013-99, Rev. 1, Standard for Emergency Lighting System Design for Passenger Cars.

APTA PR-IM-S-001-98, Rev. 1, Standard for Passenger Rail Equipment Battery System Periodic Inspection and Maintenance.

APTA PR-IM-S-005-98, Rev. 2, Standard for Passenger Compartment Periodic Inspection and Maintenance.

APTA PR-IM-S-008-98, Rev. 1, Standard for Electrical Periodic Inspection and Maintenance.

[2] For references in Italics, see Section 2 of this standard.

APTA PR-IM-S-013-99, Rev. 1, Standard for Passenger Car Periodic Inspection and Maintenance.

APTA PR-PS-S-002-98, Rev. 3, Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment.

ASTM E 2073-02, Standard Test Method for Photopic Luminance of Photoluminescent (Phosphorescent) Markings.

49 CFR, Part 223, Safety Glazing Standards.

49 CFR, Part 238, Passenger Equipment Safety Standards.

49 CFR, Part 239, Passenger Train Emergency Preparedness.

3. Definitions, abbreviations, and acronyms

3.1 Definitions

For the purposes of this standard, the following terms and definitions apply:

3.1.1 active illumination: Illumination that is generated by electrical energy.

3.1.2 aisle: A path through a vehicle that is not bordered by walls, such as the path through the center of a coach car with rows of seats on each side**.**

3.1.3 auxiliary power system: An on-board source of electrical power (e.g., alternator / generator / car battery) typically used under normal operating conditions to supply such functions as lighting, air conditioning, etc.

3.1.4 candela (cd): Unit of luminous intensity in both SI and English measurement systems. One candela is one lumen per steradian (lm/sr). It is almost exactly equal to the obsolete unit called the candle.

3.1.5 car: A passenger-carrying rail vehicle.

3.1.6 color temperature: a numerical descriptor of the hue of a light source. It is expressed in terms of degrees on the Kelvin scale, and refers to the temperature of a black-body radiator that produces light of the same hue as the source specified. Low color temperatures correspond to reddish sources, such as, candle flames or incandescent lamps. Higher color temperatures are associated with cool-white fluorescent lamps, LEDs, blue sky and several types of new lighting technology.

3.1.7 dual-mode: Utilizing a combination of active (electrically powered) and passive (PL) light sources.

3.1.8 electroluminescence (EL): Luminescence resulting from the application of an alternating electrical current to phosphor.

3.1.9 exit path: The path or corridor through a rail car that provides the preferred path of evacuation from the car.

3.1.10 externally illuminated: The light source is contained outside the sign, device, legend, marking, or path that is illuminated**,** e.g., a non-photoluminescent sign with a light source shining on its surface. This source may be designed to provide dedicated illumination for a specific location or general emergency illumination. Fluorescent or incandescent lamps are typically used.

3.1.11 foot-candle: A unit of illuminance. One foot-candle is one lumen per square foot (Lm/ft^2). In the international system (SI), the units of illuminance are lux (1 fc = 10.76 lux).

3.1.12 head-end power (HEP): A system by which electrical power is provided to railroad vehicles from a central source via a trainline system. The source of power can be a locomotive or a power car (Wayside supply from catenary, third rail, or trackside can also be transformed into HEP as it passes through the power system.) HEP is used under normal operating conditions to provide electrical power to the passenger equipment systems, such as "normal" lighting. In the United States, 480 VAC, 3-phase systems are most common.

3.1.13 high performance photoluminescent (HPPL) material: A photoluminescent material that is capable of emitting light at a very high rate and for an extended period of time. For this standard, the minimum luminance value for HPPL is 7.5 mcd/m^2, for 1.5 hours after removal of the charging light source. Unless otherwise permitted by this standard, for rating purposes, the charging light source required is a fluorescent lamp with a color temperature of 4000-4500°K that provides an illuminance of no more than 1 fc for a duration of no more than 1 hour.

3.1.14 HPPL material - former: A material that is capable of emitting light at a high rate and for an extended period of time. For this standard, the minimum luminance value for HPPL is 7.5 milli-candela per square meter (7.5 mcd/m^2), for 1.5 hours after removal of the charging light source. Unless otherwise permitted by this standard, for rating purposes, the charging light source is specified as a fluorescent lamp with a color temperature of 4000-4500°K providing an illuminance of no more than 5 fc on the test sample for a duration of no more than 1 hour.

3.1.15 illuminance: The amount of light (luminous flux) falling on a specific (unit) surface area (e.g., one square foot). English units are foot-candles (fc) or lumens per sq. foot (Lm/ft^2). International units (SI) are lumens per sq. meter (Lm/m^2) or lux (lx). (1 fc = 10.76 lux).

3.1.16 independent power source: A sealed battery or other energy storage device located within the car body designed to power one or more emergency light fixtures or other devices when the normal HEP, main car battery, auxiliary power, and/or wayside power are unavailable.

3.1.17 internally illuminated: The light source is contained inside the sign, device, marking, or legend that is illuminated, e.g., a light fixture with the word “EXIT” printed on the diffuser. The light source is typically incandescent, fluorescent, EL, or LED.

3.1.18 lighting, emergency: Lighting mode that is available whenever power for the normal lighting is unavailable. The main car battery or one or more independent power sources can be used to supply the power to operate the fixtures that provide emergency lighting.

3.1.19 lighting, normal: Lighting mode that is available when the car is in operation with the normal power system.

3.1.20 low-location: Area of the rail car defined by a volume that includes the entire area of the floor, and which extends upwards to a horizontal plane four (4) feet (1.22 m).

3.1.21 luminaire: A device to produce, control, and distribute light. A complete unit typically consisting of one or more lamps, sockets to hold and protect the lamps, optical devices to direct the light, and circuitry to provide the required electric power to the lamp(s). (Commonly referred to as a light fixture)

3.1.22 luminance: The amount of light reflected from a unit area or surface, or the amount of light emitted from a surface, e.g., electroluminescent or light-emitting diode (LED) material. English units are foot-lamberts (fl). International units (SI) are candela per square meter (cd/m^2) (also called "nits") and milli-candela per square meter (mcd/m^2). (1 fl = 3.426 cd/m^2 or 3426 mcd/ m^2.)

3.1.23 luminescence: The emission of light other than incandescent, as in phosphorescence or fluorescence by processes that derive energy from essentially non-thermal sources through excitation by radiation.

3.1.24 luminous intensity: The luminous flux per unit solid angle in the direction measured. Expressed in candelas or lumens per steradian.

3.1.25 marking / delineator: A visible notice, sign, symbol, line or trace.

3.1.26 passageway: A path through a vehicle that is bordered by walls to allow a passenger or crewmember the ability to move from one location to another.

3.1.27 passive illumination: Illumination that is generated without the use of direct electrical energy.

3.1.28 photoluminescent (PL) material: Material having the property of emitting light that continues for a length of time after excitation by visible or invisible light has been removed (i.e., self-illuminating.)

3.1.29 primary exit / primary door exit: The normal (preferred) door exit point (usually the end door) used by passengers and crewmembers to egress from the affected car in an emergency to an adjacent car located at either end of the affected car.

3.1.30 representative car: A car that shares the relevant characteristics as the cars it represents (i.e., same LLEPM layout, and charging light system for passive LLEPM systems or light fixtures and power system for electrically powered LLEPM systems).

3.1.31 secondary exit: Exit point (usually a side door) used by passengers and crew to egress from the affected car and/or the train in an emergency if the primary exit is not available or safe.

3.1.32 sign: A display board, poster placard, or marking / delineator using text and/or graphics to convey information or direction.

3.1.33 spatial average: The average of all samples taken in the vicinity of a specific location. The area of a spatial average varies. For a stairway, it comprises only the area of the stair step(s). For an aisle, the entire length of the aisle is included.

3.1.34 stairway: Continuous set of steps (not interrupted by a landing).

3.1.35 useful field of view (UFOV): Useful field of view refers to the sensory, perceptual and attentional processes that address the ability to attend to one's surroundings, detect information and identify that which demands action. In terms of behavior, UFOV includes that information which can be extracted from a glance.

3.2 Abbreviations and acronyms

ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASTM	ASTM International (formerly American Society for Testing and Materials)
CFR	Code of Federal Regulations
CIE	Commission Internationale de l'Eclairage (International Commission On Illumination)
EL	Electroluminescent
FAA	Federal Aviation Administration
FRA	Federal Railroad Administration
HEP	Head-end power
HPPL	High performance photoluminescent material
LED	Light-emitting diode
LLEPM	Low-location exit path marking
PL	Photoluminescent
PRESS	Passenger Rail Equipment Safety Standards
UFOV	Useful Field of View

4. General system requirements

The LLEPM system shall be designed to identify the location of primary door exits and the exit path to be used to reach such doors by passengers and train crewmembers under conditions of darkness when normal and emergency sources of illumination are obscured by smoke or are inoperative, except as noted in Section 5.1.2 for certain semi-permanently coupled cars.

4.1 Visual identity and recognition

The LLEPM system must be conspicuous (i.e., clearly recognizable / distinguishable), or become conspicuous within a volume as defined in section 3.1.20, immediately and automatically upon loss of power for normal lighting, under the minimum general emergency light illumination

levels as specified in *APTA SS-E-013-99, Rev. 1, Standard for Emergency Lighting System Design for Passenger Cars*. The LLEPM system shall be installed with consideration for useful field of view (UFOV) to enable passengers and train crewmembers to make positive visual identification of the exit path and primary door exits without undue hesitation, delay, or confusion.

At a minimum, the LLEPM system shall have three components:

- Primary door exit signs,
- Primary door exit marking / delineators, and
- Exit path marking / delineators.

The LLEPM system shall operate independently of the car's normal and emergency lighting systems for 1.5 hours after loss of all power for normal lighting, except as noted in Section 5.3.

4.2 Multilingual signs

At a minimum, any words included in emergency exit signage shall be in English. However, when system-specific determinations are made or are otherwise mandated by local, municipal, state, or other regulations, signage / instructions shall be written in designated language(s), in addition to English.

5. System design requirements

The LLEPM system shall include:

- An exit sign at each primary door exit, visible from a low-location (i.e., extending from the floor upward to 4 feet (1.23 m)), and a horizontal distance of 6 feet (1.93 m) from the exit along the exit path.
- Markings along the perimeter of the door or door frame visible from a low-location (i.e. extending from the floor upward to 4 feet (1.23 m)) and a horizontal distance of 6 feet (1.93 m) from the exit along the exit path.
- Markings on or around the door's operating handle.
- Markings / delineators indicating a path from all aisle seating and compartment locations in the rail car to all of the car's primary exits.

If the method for opening a primary door exit is not obvious, operating instructions shall be posted at that door's control or in its immediate vicinity in accordance with *APTA PR-PS-S-002-98, Rev. 3, Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment*.

In cars with only one designated primary door exit (e.g., when the other end door is locked or secured), additional measures shall be taken to provide emergency opening instructions for the secured primary exit or direct passengers to an alternative door exit and/or emergency window exit. Railroads shall use their passenger awareness programs to provide information regarding alternative exits by posting the information inside the car (e.g., on car bulkhead signs, seatback

decals, or seat cards) and by using one or more of the following: on-board announcements, laminated wallet cards, ticket envelopes, timetables, station signs or video monitors, public service announcements, or seat drops. If passengers are directed to an alternative door exit, and the method for opening the alternative door exit is not obvious, emergency instructions for opening that exit shall be posted at that exit location.

LLEPM signs shall comply with the text, color and respective illuminance or luminance requirements specified in *APTA SS-PS-002-98, Rev. 3.*

5.1 Location

5.1.1 Door exits

5.1.1.1 Signs

Each primary door exit or designated alternative door exit shall be clearly marked with an exit sign.

Each exit sign shall be located on or immediately adjacent to each door and placed between 6 and 18 inches (15.2 cm) above the floor.

NOTE 1-- HPPL signs/markings installed in shadowed locations should be avoided, to the extent practicable.

5.1.1.2 Marking / delineators

Each primary door exit or designated alternative door exit shall be clearly marked / delineated with HPPL marking / delineator material placed in close proximity to or on the primary door exit.

A minimum of 1-inch (2.54 cm) wide strips shall be applied to the extent practicable to both sides of the interior of each primary door exit or doorframe and shall extend from the floor to a minimum height of 12 inches (30.5 cm) above the floor. If unable to extend HPPL material from the floor directly, the marking / delineator may start at the lowest location possible (within 6 inches (15.2 cm) of the floor) and extend at least 12 inches (30.5 cm) vertically from that point. If this is not possible, sufficient HPPL material shall be placed on the door, door frame, or adjoining wall between the floor and an 18-inch (45.7 cm) vertical limit, so that the total area is at least 12 square inches (77 cm^2) on both sides. Additional material placed above 18 inches off the floor is permitted, but does not count towards this requirement. See also Note 1.

In addition, each primary or, at the option of the railroad, secondary door exit handle, latch, or operating button shall be identified with HPPL material as specified in *APTA SS-PS-002-98, Rev. 3.* See also Note 1.

5.1.2 Exit path marking / delineators

The location of the exit path shall be marked using either electrically powered (active) marking / delineators or light fixtures, or HPPL (passive) marking / delineators, or a combination of these two systems. See also Note 1.

The requirements in this section apply to both electrical and HPPL components, whether installed on walls, floors, seat assemblies, or stairs.

For passenger cars used in intercity service, and placed in service before April 7, 2008, exit path marking /delineators shall be installed by January 1, 2012.

The marking / delineator components shall be positioned so as to identify an exit path to all primary exits that is clearly visible and easily recognizable from any seat or compartment in the car, when normal lighting and emergency lighting are unavailable in conditions of darkness and / or smoke.

The marking / delineator components shall be located on the floor or no higher than 18 inches (45.7 cm) on the seat assembly, or walls / partitions of aisles, passageways, or stairways, above the plane of the floor or the nearest stair tread.

Changes in the direction of the exit path shall be indicated by the LLEPM. This indication must be placed within 4 inches (10.2 cm) of the corner in the exit path.

For passenger cars ordered before April 7, 2008, and placed in service before January 1, 2011, electrically powered path markings / delineators that are not dual mode shall have an independent power source by January 1, 2012. Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests (see Annex D.)

For passenger cars ordered before April 7, 2008, and placed in service before January 1, 2011, independent power sources for LLEPM systems are not required in passenger cars that are part of semi-permanently coupled trainsets, if the power source is a sealed battery located above the underframe of the car.

5.1.2.1 Electrically powered (active) systems

Gaps in strip marking / delineation segments/ light fixtures may be no more than 36 inches (91.4 cm) in length, to the extent practicable, and provided that a clearly visible and recognizable path to the primary exit is maintained.

A. Aisles and passageways

The marking / delineator strip material may be applied along the floor either as a continuous or intermittent strip, or upon seat assembly on one or both sides of the aisle / passageway.

If light fixtures mounted on a partition or seat assembly are used to delineate the path, these shall be applied on one or both sides of the aisle/passageway.

B. Interior stairways

The marking / delineator material shall be applied either as a continuous strip applied along the walls / partitions of at least one side of the interior stairs, or as intermittent strips applied to the riser and / or tread of each step.

When the marking / delineator material is applied to the stairway walls / partitions, it shall be applied as a continuous strip, to the extent practicable extending from the lowest to the highest step.

When the marking / delineator material is applied to the stairway treads, it shall, to the extent practicable, extend across the full width of each tread near the step nosing.

If light fixtures mounted on a partition or seat assembly are used, these shall be applied on at least one side of the aisle/passageway.

One or more wall-mounted light fixtures shall be installed on at least one side of the interior stairway to illuminate each step, from the lowest to the highest step.

5.1.2.2 HPPL (passive) systems

See also Note 1.

The width of each marking / delineator strip for aisles, passageways, and interior stairways shall not be less than 1 inch (2.5 cm) and shall be applied either as a continuous or intermittent strip.

As an alternative, intermittently placed discs of not less than 1.25 inches (3.2 m) in diameter may also be used.

If intermittent strips or discs are used, they shall be placed on both sides of the aisle, passageway or stairway; on the floor or no higher than 18 inches (45.7 cm); and where practicable, any gaps on either side of the aisle, passageway or stairway shall be staggered.

A. Aisles and passageways

HPPL marking / delineator material shall be applied continuously on the floor or no higher than 18 inches, to at least one side or down the middle of the aisle / passageway, or intermittently on both sides of the aisle / passageway, to provide a conspicuous delineation of the exit path to a person standing in the aisle / passageway.

The width of marking / delineator strips may consist of multiple parallel strips (multi-strip), as long as the sum of the widths of the multiple strips is equal to or exceeds the 1-inch (2.5 cm) wide strip and the light output (luminous intensity) per unit length of the multiple strips exceeds that of the single 1-inch (2.5 cm) wide strip marking placement.

Intermittent marking / delineator strips shall total a minimum of 6 inches (15.2 cm) in length for every 42-inch (106.7 cm) segment of exit path.

Discs shall be arranged in a distinctive, recurrent pattern. The sum of the diameters of intermittently placed discs shall total a minimum of 6 inches (15.2 cm) for every 42-inch (106.7 cm) segment of exit path.

Each passenger car ordered before April 7, 2008, and placed in service before January 1, 2011, may have 3 discs clustered in a series with no gap between the clusters exceeding 30 inches (76.2 cm).

B. Interior stairways

In all interior stairways, HPPL marking / delineator material shall be applied, either as a continuous strip applied on the walls of both sides of the stairs, or as intermittent strips applied to the riser or tread of each step.

If the HPPL marking / delineator material is applied to the interior stairway walls, the marking shall be applied as a continuous strip, to the extent practicable, extending from the lowest to the highest step.

If the HPPL marking / delineator material is applied to the stairway treads, a strip of material at least 1-inch (2.5 cm) wide shall extend, to the extent practicable, across the full width of each tread near the step nosing.

One of the following three alternatives is acceptable if the marking / delineator placement provides a clear and conspicuous visual delineation of the exit path to a person standing at the top and bottom landings:

- **Alternative 1**: 1-inch (2.5 cm)-wide "L" shaped marking / delineators shall be installed on both sides of each tread nearest to the wall**.**

- **Alternative 2**: Materials, applied to the step risers that consist of a minimum 2-inch (5.2 cm) wide strip or two 1-inch (2.5 cm) wide strips that extend, to the extent practicable, across the full width of the riser and placed at the lower half of the riser.

- **Alternative 3**: Discs of not less than 1.25 inches (3.18 cm) in diameter, placed either: 1) no more than 2.5 inches (6 cm) apart on each stair tread, near the step nosing, or 2) no more than 2.5 inches (6 cm) apart and no higher than 18 inches (45.7 cm) from the treads on both sides of the stairway walls / partitions.

5.2 Illuminance / luminance criteria

LLEPM sign / marking component illumination or luminance levels, as applicable, shall be verified in accordance with Section 6 and tested**,** maintained and repaired in accordance with Section 9.

The difference between the physical characteristics of electrically powered light fixtures / strips and HPPL materials has an impact on their visibility and thus the performance criteria and installation location within various rail car configurations. For example, it is important that HPPL material be installed in locations and orientations that provide maximum exposure to adequate charging light. In addition, dual-mode LLEPM system components can be used to increase conspicuity. Additional measures for addressing extenuating circumstances are described below and in Annex B.

5.2.1 Electrically powered systems

The light sources utilized to comply with the criteria required in this section shall be electrically powered (e.g., incandescent, fluorescent, EL, or LED).

5.2.1.1 Illuminance / luminous intensity

NOTE 2-- For point sources / strips installed in each passenger car ordered on or after April 7, 2008, or placed in service for the first time on or after January 1, 2011, each point source / strip shall comply with the following criteria:

- Incandescent: miniature lamps not less than 150 mcd mean spherical intensity with a maximum spacing of 4 inches (10 cm) between lamps.
- LED: minimum peak intensity of 35 mcd with a maximum spacing between lamps of 12 inches (30.5 cm). LED-based dual-mode components shall use either white or green charging light.

Where light fixtures are mounted on the walls or seat pedestals / frames or components, each light fixture shall provide an average illumination value of at least 0.1 fc, measured on the surface of the floor or step averaged at intervals of 30 inches (76.2 cm) or less along the center of the aisle, passageway, or stairs**.**

5.2.1.2 Luminance

The luminance value of the electroluminescent (EL) marking / delineator strip shall be at least 1000 mcd/m^2, as measured on the strip surface.

NOTE 3-- Most electroluminescent components have an initial luminance of more than 20,000 mcd/m^2, but they may show substantial luminance degradation (more than 80%) over their service lives. Service life estimates range from 30,000 hours to 100,000 hours (7 to 20 years) for stationary equipment.

5.2.2 Passive HPPL systems

5.2.2.1 Materials

HPPL strip marking / delineator material used for LLEPM components shall be capable of providing a minimum luminance level of 7.5 mcd/m^2, measured 1.5 hours after normal power has ceased, except as noted in Section 5.3.

5.2.2.2 Charging light

Because the illuminance levels required to provide sufficient charging vary according to the type of light source used, the minimum charging light values, are as specified in Table 1.

These illuminance values shall be measured with a light meter meeting the requirements in Section 6 and with the sensor:

1) placed flat against the surface of the LLEPM sign / marking / delineator, or
2) dragged along the aisle while its data is recorded by a notebook computer or data logger, as described in Annex C, for exit path marking / delineators installed near or in the floor.

Table 1. Minimum Illuminance Values for Charging HPPL Materials

HPPL Illuminance FC (lux)	TYPE OF LUMINAIRE (Charging Light)
0.8 (8.6)	Cool-white LED (6500º K)
0.9 (9.7)	Warm-white LED (4700º K)
1.0 (10.8)	Cool-white Fluorescent (4000 - 4500ºK)
1.5 (16.1)	Warm-white Fluorescent (3000 - 3500ºK)
3.5 (37.7)	Incandescent (2900 ºK)

HPPL materials certified by an independent test laboratory to meet Table 1 with the lower amount of charging light are permitted for use at that location as long as the specified amount of light is available.

HPPL signs / markings certified by an independent test laboratory to be capable of meeting the specifications in 3.1.13 that are located in partitioned vestibules / compartments / passageways that are no longer than 5 ft (1.5 m) longitudinally (including partially portioned vestibules) are not subject to the illuminance requirements in Table 1.

To ensure that the normal lighting system provides an adequate charge to the HPPL system, luminaires (light fixtures) shall be located in the proximity of each HPPL component and oriented to ensure that the HPPL material is adequately exposed to charging light. Annex B contains information that railroads can use to ensure sufficient light is available.

Luminaires (light fixtures) located in the proximity of each HPPL component shall be specified such that their light-dispersion patterns provide the above listed minimum illuminance levels at the surface of the component.

NOTE 4-- Consideration should be given to other illumination requirements for the area, including those for *APTA SS-PS-002-98, Rev.3* and ADA.

5.2.3 Dual Mode

NOTE 5-- Dual-mode systems comprised of active and passive components shall be designed so the HPPL material is adequately charged by an active light source in order to comply with the minimum luminance criterion of 7.5 mcd / m^2, measured after 1 or 1.5 hours, as applicable (see Sections 3.1.14, 3.1.13, and 5.3, after activation lighting has been removed / ceased operating.

5.3 Grandfathering of LLEPM PL components

PL materials that meet the luminance levels of at least 7.5 mc / m^2 for at least 1 hour following a charge with the illuminance values in Table 2 are grandfathered. If PL materials certified by an independent laboratory to meet the former definition of HPPL (see Section 3.1.14) are charged with the illuminance levels in the first column of Table 2, such materials are presumed to meet these luminance levels. PL signs / markings / delineators installed in cars on or before April 7, 2008, and certified by an independent test laboratory to comply with these PL luminance criteria are grandfathered if any of the following conditions are met:

1) The location where they are installed receives the minimum illuminance listed for the type of luminaire used for charging as specified in Table 2. The illuminance values shall be measured with a light meter meeting the requirements of Section 6 and with the sensor:

   - placed flat against the surface of the LLEPM sign / marking / delineator, or
   - dragged along the aisle while its data is recorded by a notebook computer or data logger, as described in Annex C, for exit path marking / delineators installed near or in the floor.

2) The illuminance values shall be measured with a light meter meeting the requirements in Section 6, except that its cosine error may be as specified in CNS 5119 (see Annex C) and with the sensor placed flat on the floor at any point within a horizontal distance of 3 feet (1 m) of the sign / marking / delineator. The illuminance values shall be at least five (5) times greater than the values listed in Table 2.

3) Signs / markings made of materials meeting the former definition of HPPL located in partitioned vestibules / compartments / passageways that are:

   - No longer than 5 ft (1.5 m) longitudinally (including partially partitioned vestibules); or
   - Between 5 ft (1.5 m) and 10 ft (3 m) in length measured longitudinally (including partially partitioned vestibules) that are charged by incandescent luminaires, and have:
     - Locator signs in the seating area that comply with Section 5, and:
     - Dimensions of at least:
       - 2 inches (5 cm) in letter height, or
       - 21 square inches (135 cm^2) in area.

NOTE 6-- Some signs / markings may have to be replaced or some illumination levels increased.

If the ambient (normal charging light) illuminance is less than the required criteria specified, railroads can take several actions described in Annex B to increase the charging light levels.

Table 2. Minimum Illuminance Values for Charging HPPL (Former and Current Definitions) Materials – Grandfathering

ILLUMINANCE VALUE - FC (Lux)		TYPE OF LUMINAIRE (Charging Light)
Certified Under Former Definition of HPPL	Certified Under Current Definition of HPPL	
1.6 (10.8)	0.8 (8.6)	Cool-white LED (6500º K)
1.8 (19.4)	0.9 (9.7)	Warm-white LED (4700º K)
2.0 (21.5)	1.0 (10.8)	Cool-white Fluorescent (4000 - 4500ºK)
3.0 (32.3)	1.5 (16.1)	Warm-white Fluorescent (3000 - 3500ºK)
7.0 (75.3)	3.5 (37.7)	Incandescent (2900 K)

Existing stocks of PL material held in inventory as of April 7, 2008, that meet the former definition of HPPL may be installed only in locations that qualify under one of the conditions listed above and which are not shadowed by structural elements or other permanent fixtures.

6. Evaluation measurements and tests

To verify that the LLEPM system component design complies with Section 5.2, railroads shall ensure that a qualification test is conducted on at least one representative car for each LLEPM layout operated by the railroad, in accordance with this section and Annex C.

For equipment placed in service before January 1, 2008, the car(s) shall be randomly selected and this test shall be conducted by December 31, 2008.

For equipment placed in service for the first time on or after January 1, 2008, the first car to have the LLEPM system installed may be tested and this test shall be completed prior to the cars release for operation in revenue service.

The railroads shall confirm that LLEPM system components comply with the minimum required illumination or luminance criteria, as applicable, for the specified duration.

To ensure accurate illuminance measurements including measurements on vertical surfaces at which the angle of incident light is large, the light meter must be designed to take such measurements and possess:

- Basic accuracy: ± 3% of reading ±1 digit or better,
- Resolution: 0.01 fc or better,
- Cosine error: no more than 6%, measured at 50 degrees, and
- Color correction to CIE photopic curve.

Unless the floor measurement value is known to be at least 5 times the value in Table 2, a 6.5 foot (2 m) separation between the sensor head and the display must be used to ensure that the close proximity of the person taking the measurements does not affect the readings.

6.1 Electrically (active) powered systems

Manufacturer / supplier provided independent laboratory certified test report results shall show that electrically powered components have been photometrically tested as appropriate for the type of light source:

1) Luminance for EL markings, and
2) Luminous intensity for point sources and comply with Section 5.2.1.

Railroads shall confirm that the power supply for electrically powered LLEPM components will maintain the operating voltages specified by the sign / marking manufacturer / supplier for at least 1.5 hours, except as noted in Section 7.

To ensure compliance with Section 5.2.1.1, electrically illuminated signs / markings, measurements shall be conducted in accordance with Sections 6.1, 6.2, and 6.3.2 of *SS APTA SS-E-013-99, Rev 1., Standard of Emergency Lighting System Design for Passenger Cars.*

6.2 HPPL (passive) systems

6.2.1 Material luminance

Manufacturer / supplier provided independent laboratory certified test results shall show that all tested samples of passive HPPL material, as used in the finished component configurations (including any cover or protective coating if used, but not including text or graphics) comply with the minimum luminance criterion of 7.5 mcd/m^2, after 1.5 hours, when tested according to the provisions of *ASTM E-2073-07 Standard Test Method for Photopic Luminance of Photoluminescent (Phosphorescent) Markings* (www.astm.org), with the following three modifications:

- Section 8.3—Activation: The HPPL material shall be activated with a fluorescent lamp of 40W or less and a color temperature of 4000-4500^o K that that provides no more than 1 fc of illumination as measured on the material surface. The activation period will be for no more than 1 hour.
- Section 8.4—Luminance: The photopic luminance of all specimens of the HPPL material shall be measured with a luminance meter as described in 5.2 (of ASTM E-2073), a minimum of 1.5 hours after activation has ceased.

- Section 9.1.12—Luminance in mcd/m^2: The test report shall include a luminance measurement 1.5 hours after activation has ceased.

A list of independent test laboratories is contained in Annex E.

The manufacturer / supplier is required to have a minimum of one batch of material for signs / markings / delineators of a given type certified. Signs / markings / delineators of the same certified type of material can be sold to multiple customers, even with minor changes in text or typography.

6.2.2 Ambient light charge

To confirm that HPPL emergency sign / marking components are installed in locations that receive adequate charging light, illuminance measurements shall be taken in accordance with Section 6.1 of *APTA SS-E-013-99 Rev. 1* as applicable. This requirement applies to each representative car tested.

The charging light shall consist only of that provided by the car's normal lighting system. All natural or other external light shall be excluded. Several methods can be used to eliminate ambient light for accurate data collection (e.g., work at night with cars parked away from bright yard lights; locate cars in a dark, windowless shop or carwash; mask windows and vestibules with roofing paper, flooring paper, or similar opaque materials; or drape cars with opaque tarpaulins).

If the ambient light can't be reduced to 0.01 fc, there are two alternative measurements that can be used to meet the requirements in Tables 1 and 2:

1) Measure the ambient light at each location and subtract that value from the value measured with the charging light system operating;
2) If the charging light system is at least twice the required levels in Tables 1 and 2 plus the ambient light reading, consider that the required levels to be met.

To take the measurement readings, the sensor is placed on the area of the HPPL sign / marking surface location where the light is brightest (or on the floor location as permitted in Section 5.3). The observer records the reading(s) using a data collection form (see Annex C.).

The sensor and the readout device of the illuminance meter must be held in a manner so that the sensor is not affected by the observer's shadow. If light diffusers are used on the light fixtures, the measurements shall be made with the light diffusers in place.

If the ambient (normal charging light) illuminance is less than the required criteria specified (see Sections 5.2.2. and 5.3), railroads can take several actions described in Annex B to increase the charging light levels.

6.3 Recordkeeping

Railroads shall retain a copy of the car manufacturer / supplier provided certified independent laboratory test report results showing that the illuminance or luminance measurements, as appropriate, on the active area of the signage / marking / delineator component comply with the criteria specified in Section 5.2 or 5.3, as applicable, of this standard. (For HPPL systems, see Annex C.) Such records shall be kept until all cars with those components are retired, transferred, leased, or conveyed to another railroad for use in passenger service. A copy of such records shall be transferred to the accepting railroad along with any such cars.

Railroads shall retain a copy of the railroad approved illuminance test plan(s) and test results until the next periodic test, or other test specified in Section 9 is conducted on a representative car, or until all cars of that type are retired, or are transferred, leased, or conveyed to another railroad. A copy of such records shall be provided to the accepting railroads along with any car(s) that are transferred, leased, or conveyed.

7. System reliability

All LLEPM system components shall be designed so that the exit path remains conspicuous, notwithstanding the failure of any single HPPL material segment, lighting strip, light fixture, battery or other power source.

NOTE 7-- Batteries may fail to achieve normal service lives unless measures are taken to prevent their discharge when the LLEPM system is not needed. To avoid this situation, lighting circuits of LLEPM systems that use batteries for independent power sources should be turned off manually or by an automatic (voltage or timer-based) controller (e.g., when the car is not in passenger service). (See Annex D for additional guidance.)

For passenger cars ordered before April 7, 2008, and placed in service for the first time before January 1, 2011, electrically-powered LLEPM components shall continue to function so that illumination at the minimum levels are maintained for at least 1 hour after loss of normal power. Effective January 1, 2012, LLPEM components shall also continue to function independently of the main car battery.

For passenger cars ordered on or after April 7, 2008, or placed in service for the first time on or after January 1, 2011, electrically-powered LLEPM components shall continue to function so that illumination at the minimum levels are maintained for at least 1.5 hours after loss of normal power.

8. Operating Conditions

The LLEPM signs/markings/delineators shall be conspicuous under all operating conditions, including build up of dust, dirt as well as discoloration of the HPPL or light diffuser components.

All LLEPM systems shall be designed to operate without failure under the conditions typically found in passenger rail equipment, including expected mechanical vibrations and shock, as well as comply with electromagnetic interference and other criteria in *49 Code of Federal Regulations (CFR) Part 238, Passenger Equipment Safety Standards*, Sections 238.225 and 238.425.

All electrically powered LLEPM components independent power sources in passenger cars ordered on or after April 7, 2008, or placed in service for the first time on or after January 1, 2011, shall be designed to operate in all equipment orientations and after the initial shock of a collision or derailment resulting in the following individually applied accelerations:

- longitudinal: 8g,
- lateral: 4g, and
- vertical: 4g.

9. Maintenance

LLEPM system components shall be properly placed to avoid or minimize damage from water or cleaning, especially exposure to acidic car-wash solutions.

9.1 Daily inspections

Railroads shall visually inspect all LLEPM system components during the daily inspections to determine that signs / markings / delineators are present and conspicuous, and that signs and instructions are legible.

9.2 Periodic inspections and tests

Railroads shall conduct periodic inspections and tests to verify that all LLEPM system components, including power sources, function as intended.

Railroads shall test a representative sample of passenger rail cars / areas in accordance with Sections 9.2.1 and 9.2.2, using the procedures in Annex F or other statistically valid documented sampling method.

9.2.1 Electrically powered (active) systems

Railroads shall conduct tests and inspections in conformance with the requirements of *APTA PR-IM-S-008-98, Rev. 1, Standard for Passenger Car Electrical Periodic Inspection and Maintenance; APTA PR-IM-S-001-98, Rev. 1, Standard for Passenger Rail Equipment Battery System Periodic Inspection and Maintenance;* and *APTA PR-IM-S-013-99, Rev. 1, Standard for Passenger Car Periodic Inspection and Maintenance,* and *APTA PR-IM-S-005-98, Rev. 2, Standard for Passenger Compartment Periodic Inspection and Maintenance*.

NOTE 8-- Criteria for acceptable main car battery characteristics are specified in *APTA PR-E-RP-007-98.*

Railroads shall ensure that periodic tests to confirm that electrical component(s), including the emergency power source, function as intended and comply with Section 5.2 are conducted no less frequently than once every 8 years, with the first test conducted no later than 8 years after the car was placed in service for the first time.

The tests shall verify the minimum illumination / luminance level and duration of all LLEPM system components. Electrically powered components shall be photometrically tested as appropriate to the type of light source:

1) Illuminance for internally illuminated signs / markings / delineators, and

2) Luminance for EL signs / markings / delineators.

Railroads shall ensure that periodic tests to confirm that electrical component(s), including the emergency power source, function as intended and comply with Section 5.2 are conducted no less frequently than once every 8 years, with the first test conducted no later than 8 years after the car was placed in service for the first time.

If the luminance level of photometrically-tested EL signs / markings / delineators, measured in the first two randomly selected representative sample cars is at least 2000 mcd/m^2, for the duration specified (See Sections 4.1, 5.3, and 8), no further testing is required for the cars represented by the sample car tested for the periodic inspection cycle.

Other types of light sources do not require photometric testing if the main car battery / independent power source (s) that provides emergency lighting power is designed and maintained to provide the operating voltages to the sign / marking / delineator specified by the manufacturer / supplier to comply with Section 8.

Independent power sources using batteries shall be certified by their manufacturers / suppliers to be capable of maintaining operation of the sign / marking components to which they connected for at least 1 hour or 1.5 hours as required by Section 7.

For electrically powered LLEPM components that use a battery as an independent power source and have an automatic self-diagnostic module, the module shall perform discharge tests. (See Annex D for additional guidance.)

Each sealed battery shall be replaced at two-year intervals, unless equipped with a controller that automatically prevents unnecessary discharge. If so equipped, the battery-replacement interval shall be in accordance with the manufacturer's specifications, or if not specified, at least every five years.

For electrically powered LLEPM components that use capacitors as independent power sources a functional test shall be conducted, as part of the periodic inspection. Due to their long life, the self-diagnostic test and the two-year replacement requirements do not apply to capacitor-based energy storage devices. PL (passive) systems.

9.2.2 PL (passive) systems

Railroads shall conduct tests and inspections in conformance with the requirements of *APTA PR-IM-S-005-98, Rev. 2, Standard for Passenger Compartment Periodic Inspection and Maintenance*.

Railroads shall also conduct tests specified in this section to verify that all PL (passive) interior emergency signage system components receive sufficient illuminance from the charging light to provide the required luminance for the required duration (see Sections 4.1 and 5.3). Charging light shall be photometrically tested as appropriate to the type of light source.

Railroads shall conduct periodic illuminance tests to confirm that PL components receive adequate charging light, no less frequently than once every 8 years, with the first test conducted no later than 8 years after the car was placed in service for the first time, for only the following PL-components:

1) HPPL signs / markings / delineators placed in areas designed or maintained with normal light levels of less than 5 fc.
2) Grandfathered PL materials, where the sign / marking / delineator is placed in an area designed or maintained with normal light levels of less than 10 fc.

If all of the illuminance levels in the first two randomly selected representative sample cars exceed the minimum required to charge the PL components required by this standard by at least a factor of 2, no further testing is required for the cars represented by the sample car tested for the periodic test cycle.

9.3 Defect reporting, repair, and recordkeeping

Illegible, broken, damaged, missing, or non-functioning components of the LLEPM system, including the normal and emergency power systems, shall be reported and repaired in accordance with railroad procedures that comply with FRA *(49 CFR, Part 238)* defect reporting procedures.

Recordkeeping shall be in accordance with railroad procedures that comply with FRA (*49 CFR, Part 238)* recordkeeping procedures.

Annex A (informative)

Bibliography

[B1] ASTM E-2030-047, Standard Guide for Recommended Uses of Photoluminescent Safety Markings.

[B2] ASTM E-2072-04, Standard Specification for Photoluminescent (Phosphorescent) Safety Markings.

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[B4] Demaree, J. "Examination of Aircraft Interior Emergency Lighting in a Postcrash Fire Environment." Federal Aviation Administration, FAA Technical Center, Final Report. No. FAA-DOT/FAA/ct-82/55.

[B5] Deutsche Industrie Norm (DIN) 67510, Parts 1-4: German Standard: Phosphorescent Pigments and Products, January 1992.

[B6] Federal Aviation Administration (FAA). Advisory Circular 25-812-1A, Floor Proximity Emergency Escape Path Marking, 5/22/89.

[B7] FAA. Advisory Circular 25-812-2, Floor Proximity Emergency Escape Path Marking Systems Incorporating Photoluminescent Elements, 7/24/97.

[B8] Illuminating Engineering Society (IES), Handbook Reference and Applications, Chapter 29: Emergency, Safety and Security Lighting, 9th edition, 2000.

[B9] International Marine Organization (IMO) Resolution A.752 (18), Nov. 4, 1993, Guidelines for the Evaluation, Testing and Application of Low-Location Lighting on Passenger Ships.

[B10] International Standards Organization (ISO) 3864-1: 2003, Graphical Symbols—Safety Colours and Safety Signs—Design Principles for Safety Signs Used in Workplaces and Public Areas (First edition 2002, Corrected version 2003)

[B11] ISO 7010: 2002, Graphical Symbols—Safety Colours and Safety Signs—Safety Signs Used in Workplaces and Public Areas. 1st Edition.

[B12] ISO 16069: 2004 *Draft* Graphical symbols—Safety Signs— Safety Way Guidance Systems. TC 145 /SC 2

[B13] ISO 9186, 2001, Graphical Symbols—Test Methods for Judged Comprehensibility and for Comprehension. 2nd Edition.

[B14] ISO 17398:2004, Safety Colours and Safety Signs – Classification, Performance and Durability of Safety Signs.

[B15] McLean, G.A., and C.B. Chittum. Performance Demonstration of Zinc Sulfide and Strontium Aluminate Photoluminescent Floor Proximity Escape Path Marking Systems. Federal Aviation Administration. Office of Aviation Medicine. Final Report. No. DOT/FAA/AM-92/2.

[B16] National Fire Protection Association (NFPA) 70, National Electrical Code, Quincy, MA. 2006.

[B17] NFPA 101 Life Safety Code, Chapter 7, Means of Egress. Quincy, MA, 2006.

[B18] NFPA 130, Fixed Guideway and Passenger Rail Systems, NFPA, Quincy, MA, 2006.

[B19] Rasmussen, P.G, Chesterfield, B.P., and D.L Lowrey.Readability of Self-Luminated Signs Obscured by Black Fuel-Fire Smoke, Federal Aviation Administration (FAA), Office of Aviation Medicine (OAM), Final Report. No. FAA-AM-80-13.

[B20] Rasmussen, P.G., Garner, J.D., Blethrow, J.G., and D.L Lowrey.Readability of Self-Luminated Signs in a Smoke Obscured Environment, FAA/OAM.Final Report No. FAA-AM-79-108.

[B21] UL 924, Standard for Emergency Lighting and Power Equipment.9th Edition, dated February 24, 2006. Effective August 24, 2006.

[B22] UL 1994, Standard for Luminous Egress Path Marking Systems, Third Edition, dated January 30, 2004, including revision as of February 14, 2005.

[B23] 14 CFR, Part 25, Airworthiness Standards, Transport Category Airplanes: Subpart D, Design and Construction, Subsection 25.812, Emergency Lighting, (e) floor proximity emergency exit path marking.

[B24] 14 CFR, Part 121, (Special Federal Aviation Regulations) Operating Requirements: Domestic, Flag, and Supplemental Operations, Subpart K, Instrument and Equipment Requirements, Subsection 121.310, Additional Emergency Equipment.

Annex B (informative)

HPPL material technical considerations

B.1 Variables

Five variables that affect the visibility of the HPPL material / component are:

- Location of the material in relation to the activating charging light;
- Illuminance charging levels provided by ambient light;
- Amount of time that the HPPL material component is exposed to light;
- Type of activating light source; and
- Energy-storage efficiency of the HPPL material.

The location of the HPPL material in relation to the activating light source and any objects that cast shadows on the material have a great impact on the illuminance provided by the charging light. Accordingly, HPPL material should not be located in shadowed areas.

Cool-white fluorescent lamps producing an illuminance level of 2 fc have been shown to provide sufficient charging light for the former definition of HPPL material (see Section 3.1.14) used in passenger rail cars. Adequate charging light for HPPL materials / components is generally available at most locations, except directly under the seats, or if there are overhangs or other obstructions that block light from reaching the material / component. Signs/markings certified according to the former definition of HPPL (see Section 3.1.14) require at least twice as much illuminance as HPPL material (see Section 3.1.13) to deliver the same luminance. HPPL materials certified to the former definition were usually designed with a large safety factor so that they do not actually require 5 times as much light for charging as the HPPL material defined in Section 3.1.13.

Another variable is the available HPPL charging time. The adequate charging time at 1 fc is at least ½ hour from dark storage until departure.

The type of charging light that is used will affect the amount of illumination required to charge the LLEPM components adequately. Most of the visible spectrum (red, orange and yellow) of a light source is not useful for charging PL materials. Short-wave length ultraviolet light is the most effective part of the light spectrum for charging PL materials. Photons of longer wavelength do not have enough energy to excite the electrons of the PL material. For example, 1 fc of illumination from a commonly available cool-white fluorescent lamp will provide sufficient illumination to meet the HPPL luminance criterion. However, 1 fc of illumination from commonly available warm-white fluorescent and incandescent lamps will not. If warm-white fluorescent lamps are used, the minimum charging light level must be at least 50% higher. If incandescent lamps are used, the minimum charging light level will be more than three times higher than is sufficient with cool-white fluorescent lamps.

White LED light contains a higher proportion of short-wave light, and is thus somewhat more effective than cool-white fluorescent light for charging. In addition, since LEDs are fundamentally unidirectional light emitters, luminaires that use them must be specifically designed to disperse light through the use of multiple emitters pointing in different directions, reflectors and/or diffusers. Therefore, it is important that procurement documents explicitly state the illuminance levels required on the surface of the PL signs / markings.

In addition to these five variables, an important consideration is the type of light meter used to measure the charging light illuminance and the placement of the meter sensor in relation to the HPPL material both of which will have an impact on the ability to accurately measure the illuminance level provided by the activating light source. Light meters are designed to respond to light the same as the human eye does and thus measure only the visible light emitted by both the charging source and the PL material. Although invisible ultraviolet light is the most effective part of the light spectrum for charging PL materials, standard light meters do not register the ultraviolet light emitted by the charging light. Moreover, the weighting factor for visible violet and blue light is small. Therefore, light meter readings of charging light can be misleading if the light source is different from the specified cool-white fluorescent source used for certification (i.e., laboratory) testing. See Annex C for further information relating to light meters.

B.2 Alternatives to increase charging light output

If, during the interior verification tests or periodic inspections, the normal charging light fails to meet the minimum illuminance criterion using normal lighting, there are several actions that can be taken to increase the charging light levels:

- Check the light fixtures near the test samples to ensure proper working order.
- Clean light fixtures and check to ensure that the diffusers not yellowed with age. Old, dirty fixtures have been measured with less than half the light output of clean ones with new diffusers.
- Check fluorescent tubes to ensure they are not near the ends of their service lives, where light output drops significantly.
- Relocate signs / markings / delineators.
- Replace warm white fluorescent lamps with cool white fluorescent lamps.
- Replace/ supplement incandescent luminaires with fluorescent or LED luminaires.
- Replace frosted light diffuser lenses with clear lenses.
- Replace existing fluorescent tubes with those of recent design that provide 10 - 15% more light for the same wattage rating and double the service life.
- If the charging light performance criterion cannot be met after taking any of the above actions, then either install:

- PL signs / markings / delineators verified by the manufacturer / supplier provided independent laboratory certified test result to exceed HPPL requirements sufficiently that they can provide a luminance of 7.5 mcd/m^2 after 1 or 1.5 hours, as applicable, after charging with the whatever normal lighting is available at the sign / marking / delineator location in question, or

- Dual-mode or actively illuminated components with an independent power supply.

Annex C (informative)

Procedures for measuring charging light illuminance

C.1 Equipment

Examples of hand-held meters on the market with adequate accuracy and sensitivity for this application are illustrated in Figure C1:

- Minolta T-10 Illuminance meter and A20 and A21 adapters and LAN cable,
- Gigahertz-Optik X9 1 with VL 3704 illuminance detector, or
- Hagner E4-X digital luxmeter.

Other meters that meet the performance specifications listed in Section 7 are also acceptable.

Illuminance sensors may need recalibration if the meter is dropped. Special care is required to avoid this. Gigahertz-Optik offers an optional foam rubber shock protector for its sensor.

Railroads with fleets consisting entirely of brightly illuminated cars may forego the use of a meter with precise off-axis response, because high levels of floor illumination can be used to establish that illumination on vertical surfaces is adequate for charging PL LLEPM components. Low-cost meters that conform to CNS 5119 [3], Class II (which permits unlimited errors for angles of incidence greater than 60º) may be used for floor and arm-rest level measurements of illumination. Because field data have shown that illuminance values on vertical surfaces are at least 20% of the illuminance on adjacent floors, the floor measurements made with inexpensive meters can be used to demonstrate compliance with this standard whenever the values at the floor are five times greater than required illuminance on the surface of the LLEPM component in question. Meters for this application are widely available from vendors such as Extech, TES, Tenmars, etc.

Other considerations: The Minolta meter can be set to readout in foot-candles or lux; the other meters readout in lux only. The Minota and Gigahertz-Optik meters have RS-232 data outputs and require an external USB adapter to work with most notebook computers. The Hagner meter has an analog data output and requires an external USB data-acquisition adapter. The Minolta meter has a detachable head that can be connected to the meter body with ordinary LAN cable of 65. ft (2 m) provided the optional A20 and A21 adapters are purchased. The other meters have 6.5 ft (2 m) cables permanently attached to the sensor.

[3] CNS 5119 is a standard developed in Taiwan. It is available for viewing in Mandarin at: http://www.cnsonline.com.tw/en/.

Figure C1. Typical meters for illuminance measurements

C.2 Data recording

To take the measurement readings, the sensor is placed on the area of the HPPL LLEPM component surface location where the light is brightest (or on the floor location as permitted in Section 5.3). The observer simply records the reading(s) using a form similar to that shown in section C.4.

The sensor and readout device of the illuminance meter should be held in a manner so that the readout device can be read without the observer's shadow affecting the readings.

C.3 Computerized data collection

The illuminance measurements described in Section 5 for the doors, vestibules, stairs, etc., must be performed by manually positioning the light sensor at each of the designated locations. However, the numerous aisle measurements to determine the minimum average illumination levels required in Tables 1 and 2 can be taken much faster and more accurately using a computer. The computer data collection technique is based on moving/dragging a sensor down the aisle at a slow, steady pace while readings are captured to a notebook computer or data logger at the rate of at least one reading per second.

Although no special apparatus is needed to collect floor-level measurements, it is strongly recommended that the notebook computer, light meter, and any adapters be attached to a tray or similar carrying device with hook-and-loop tape so that they can be easily and safely moved together.

The spatial average is calculated with spreadsheet software based on 60 or more samples, i.e., the data collector should walk at the rate of about one foot per second. The software will also find the minimum value in each set of readings and may be used to generate a graphic profile of illuminance levels along the length of the car.

As noted in Section 7, the minimum test period duration is either 1.5 hours or 1 hour. All illuminance light levels are measured and recorded immediately at start of test, at the halfway time point, and again at the end of the final time duration.

C.4 Timing of readings

Readings should be taken at least 15 minutes after the normal illumination charging light is placed in operation to allow the lamps to reach full output and per Section 6.

C.5 Sample illuminance charging light survey form

See next page

LLEPM sample illuminance / charging light survey form

RAILROAD PROPERTY: / LOCATION			
CAR BUILDER:			
CAR TYPE / SERIES / CONFIGURATION / YEAR:			
CAR PLATE #:			
DATE:			
DATA COLLECTOR'S NAME			
LIGHT METER USED			
START TIME:	END TIME:		
All measurements are expressed in foot-candles			
MEASUREMENTS			
LOCATIONS		A-end	B-end
End-frame door sign /control / instructions			
Vestibule door, location 1			
Vestibule door, location 2			
Stairs, location 1			
Stairs, location 2			
Aisle, location 1			
Aisle, location 2			
Crew area (if any)			
Other special area			
Passageway, if any			

Notes

Use the following to describe the make/model/wattage rating/cleanliness, etc., of the emergency charging light fixtures, etc.

Annex D (informative)

Automatic testing of electrically powered LLEPM systems that use batteries as independent power sources

Electrically powered LLEPM components using independent power sources have important advantages since they are not vulnerable to loss of the main car battery power supply and/or damage to the main car battery power supply wiring. However, for the independent power supply to the LLEPM system to be reliable and operate when necessary, multiple individual batteries must be periodically tested for each rail car (for cars with only two such batteries, each one must be tested).

Manual testing requires that a worker first determine that all independent power sources using batteries have been connected to a source of charging power for the necessary amount of time to reach full charge. Then, car-by-car, the charging power must be disconnected and the LLEPM system switched into emergency mode. After the prescribed 1 or 1.5 hour time period for discharge, the worker must then revisit each car and note which LLPEM components are working properly and which are not. While such tests are in progress, other kinds of maintenance work are effectively precluded by the lack of light inside the car.

To avoid the substantial labor costs of conducting periodic discharge tests of these independent power sources, manufacturers of door emergency exit sign systems for buildings have developed self-test modules for their battery ballasts that perform periodic discharge tests automatically. (A discharge test is necessary for independent batteries because they are sealed devices and therefore cannot be tested by the specific-gravity method used for the main car battery.)

These self-test modules display the results of the most recent test by means of a multi-color LED on the light fixture. For a typical fixture, the LED can indicate any of the following conditions:

CONDITION		**STATUS INDICATION**
Normal mode		Steady green
Self-testing		Flashing green
Emergency mode		Off
Insufficient charge		Flashing red / green
Battery pack failure		Single-flash red
Emergency lamp failure		Double-flash red
Self-diagnostic module failure		Triple-flash red
Under / over charge		Quadruple-flash red

The status indication remains displayed until the next scheduled periodic test or until a repair is performed. Only a momentary observation is required to see that a unit is functioning normally. Only failed components require action by maintenance staff.

Automatic testing offers the important advantage of allowing one worker to determine the condition of every LLPEM component in the time it takes to walk the length of an entire train and requires no special preparation. In addition, it is not necessary to turn off normal lighting, so there is no interference with other inspection and maintenance activities.

All of the test modules on the market are microprocessor-based. The frequency and duration of the discharge tests are specified in software. Test modules for the commercial building market perform 5-minute discharge tests at 30-day intervals and 30-minute discharge tests at 6-month intervals.

The economics of automatic testing of independent power sources using batteries are persuasive. Battery packs have an average life of more than six years or about 500 discharge cycles, whichever comes first. However, a small percentage will fail prematurely. The current retail price of an automatic self-test module is about $80 in single units - about equal to the cost of a replaceable battery and substantially less than the cost of a battery ballast with a non-replaceable battery. Compared with replacing all batteries at two-year intervals, use of automatic testers and replacement of batteries at the time of actual failure will be substantially cheaper over the life of the car on a materials-cost basis alone. Additional savings will accrue because of the labor costs avoided from replacing all batteries three or more years before they actually fail.

Annex E (informative

Test laboratories

E.1 ASTM International (American Society for Testing and Materials)

At the time this document was authorized**,** the following independent test laboratories could perform the ASTM E-2073 test, as modified in section 6.2.1 of this standard to measure the luminance of HPPL material.

California Institute of Electronics
and Material Science
2115 Flame Tree Way
Hornet, CA 92545
Tel: 951-929-2659
Contact: Lev Berger
info@CIEMS.com

Gamma Scientific
8581 Aero Drive
San Diego, CA 92123
Tel 858-279-8034
Fax 858-576-9286
Contact: Eric Nelson
www.gamma-sci.com

Hoffman Engineering Corporation
8 Riverbend Drive
P.O. Box 4430
Stamford, CT 06907-0430
Tel: 203-425-8900
Fax: 203-425-8910
Contact: Jim Delancy
www.HoffmanEngineering.com

Intertek ETL Simko
3033 U.S. Route 11
Cortland, NY 13045
Tel: 800-345-3851
Fax: 607-758-6637
Contact: David Ellis
www.ETL.Simko

Underwriters Laboratories, Inc.
1655 Scott Blvd.
Santa Clara, CA 95050
Tel: 408-985-2400
Fax: 408-556-6085
www.ul.com

E.2 Underwriters' Laboratories (UL)

Underwriters' Laboratories (UL) has issued *UL 1994, Standard for Luminous Egress Path Marking Systems* [B22] [4]. *UL 1994* includes requirements for egress path marking installed for buildings in accordance with *NFPA 70, National Electrical Code* [B16] and *NFPA 101, Life Safety Code* [B17]. The *NFPA Life Safety Code* and *UL 1994* requirements now reflect acceptance of PL signs for use in buildings.

While this APTA standard contains requirements consistent with the general concepts of *UL 1994*, the UL tests and performance criteria are not considered to be appropriate to evaluate passenger rail car LLEPM systems.

[4] The numbers in brackets correspond to those of the bibliography in Annex A.

Annex F (informative)

Representative sample sizes – Periodic maintenance

Either of the following two sampling methods is acceptable.

F.1 ANSI / ASQ

The American National Standards Institute (ANSI) and the American Society for Quality (ASQ) have developed detailed procedures for calculating the size of a representative sample depending on population size, variance, and required levels of statistical confidence. These may be found in *Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming (ANSI / ASQC Z1.9-1993)*. The ANSI / ASQC minimum sample size for a population of up to 8 units is 3 units. Specification of minimum sample sizes for fleets of more than 8 cars requires previous knowledge of the variance in the test parameter of interest. In the absence of such knowledge, a common rule of thumb is to plan to test 15 units and conduct a running analysis of variance as the test proceeds. If the variance among samples is small, it is usually possible to establish 95% confidence with a total of 5-10 samples.

F.2 Simplified sampling method

A simplified method of conducting the tests consists of the following:

1) Select five (5) cars / areas at random from each car/area:
   - Inspect cars / areas to ensure that there are no defects, such as burned out lamps, weak batteries, etc., and
   - Follow the test preparation procedures described in Section 7.1.
2) Take all of the measurements described in Section 6 and Annex C.
3) If all 5 cars / areas comply with all minimum criteria required by Sections 5, 7, and 9, no further action is required.
4) If one or more cars / areas fail to meet minimum criteria:
   - Determine and document the extent and cause of the failure and perform repairs to car(s) / area(s).
   - Continue taking measurements on cars / areas randomly selected without replacement (not previously tested) until at least ten (10) successive cars / areas or all cars / areas comply with all minimum criteria in Sections 5, 7, and 9.
     - If a pattern of failures becomes apparent, (i.e., occurs repeatedly), determine the cause, document, and implement a fleet-wide redesign / repair to correct the defect.
     - Inspection / testing may be interrupted until this repair has been completed.
   - Confirm correction of failure / defect by inspecting / testing a sample of ten repaired cars / areas (or all cars / areas) to verify that they comply with all of the minimum criteria in Sections 5, 7, and 9.
5) Retain records for possible FRA inspection.